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RESEARCH FOR BETTER QUALITY IN DRIED FRUITS

Raisins

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

THIS REPORT is one of four on dried fruit research conducted during 1958 and 1959 at the Western Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture, Albany 10, Calif. The Dried Fruit Industry Research Advisory Committee has worked closely with this division in support and evaluation of this research program. The assistance of the following groups is gratefully acknowledged:

California Dried Fig Advisory Board
California Raisin Advisory Board
California Prune Advisory Board
Dried Fruit Association of California

Valuable technical assistance was provided by E. C. Marshall, Mrs. J. G. Harris, and D. C. Patterson.

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This report was prepared in the Western Utilization Research and Development Division, 800 Buchanan Street, Albany 10, Calif.

RESEARCH FOR BETTER QUALITY IN DRIED FRUITS

RAISINS

F. S. Nury, D. H. Taylor, and J. E. Brekke

The average yearly production of raisins in California in recent years has been about 200,000 tons with a farm value of nearly 45 million dollars (18).[1]

A substantial quantity of processed raisins is packed in transparent bags and foil-wrapped cartons for consumer use. These are held under various atmospheric conditions that may adversely affect quality and thus reduce acceptability and per capita consumption. Numerous studies dealing with storage stability of dried fruits (2, 3, 8, 11, 15, 17, 19) have supplied valuable information dealing primarily with bulk storage of dried fruits; most of this work has been on cut dried fruits.

The purpose here is to report research on the chemical, physical, and organoleptic changes that take place in retail packages of raisins under a wide variety of atmospheric conditions. This research is part of a program of which the objectives are: first, to provide growers and the packers with specific information on changes that take place in their products; second, to indicate preventive measures, through improved processing and better handling practices; third, to establish new and improved quality tests and analytical methods.

For the past several years, about 10,000 tons of Golden Bleached raisins have been produced annually. The common practice is to check the skins of Thompson Seedless grapes by dipping in a hot weak solution of lye, wash the grapes, hold in fumes of burning sulfur, and dehydrate. The product is a golden-colored raisin. The sulfuring step is usually repeated before further processing. Golden Bleached raisins are used chiefly in fruit-cakes and other bakery products.

Little is to be found in the literature on stability of Golden Bleached raisins. An early publication (5) had to do with examination of sulfured fruits. More than 40 years ago, Bioletti and Way (4) reported the use of sulfur to save raisins from deterioration. In 1921, Cruess (6) mentioned work on dehydration of grapes treated in fumes of burning sulfur. Later

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[1]Numbers in parentheses refer to Literature Cited, p. 25.

Table 1.--Analyses of regular raisins used in the study

Determinations	Bags(K202)	Cartons
Moisture (by vacuum-oven method), pct--	16.08	16.16
Moisture (Dried Fruit Assoc. moisture meter), pct----------	16.40	16.40
Sugar content, pct. Total----------	70.60	71.20
Reducing----------	70.20	71.00
Fructose----------	39.20	39.30
Glucose----------	31.00	31.70
Sucrose----------	.40	.20
Crude fiber, pct.----------	.98	.92
Nitrogen, pct----------	.54	.58
Ash, pct----------	1.89	1.80
Acidity (ml. of 0.1N NaOH to bring 100-gram sample to pH 8)----------	233.8	237.4

Table 2.--Analyses of Golden Bleached raisins used in the study

Determinations	Bags(K202)	Cartons
Moisture (by vacuum-oven method), pct--	16.05	14:32
Moisture (Dried Fruit Assoc. moisture meter), pct----------	15.7	13.4
Sulfur dioxide (PPM)----------	1450	1280
Sugar content, pct. Total----------	71.2	74.6
Reducing----------	70.7	73.7
Fructose----------	40.0	42.4
Glucose----------	30.7	31.3
Sucrose----------	.5	.9
Crude fiber, pct----------	.82	.83
Nitrogen, pct----------	.46	.50
Ash, pct----------	1.77	1.72
Acidity (ml. of 0.1N NaOH to bring 100-gram sample to pH 8)----------	245.0	246.1

publications (9, 14) describe the method of applying sulfur dioxide and other operations in production of Golden Bleached raisins.

Materials and Methods

The raisins used in these experiments were processed in a commercial plant in the San Joaquin Valley of California in the crop year 1957. They were regular and Golden Bleached Thompson Seedless raisins from lots that were distributed to the retail trade.

Two lots of each fruit packed in saran-treated cellophane bags (K202) and cartons with foil-laminated paper overwrap were obtained. Each lot consisted of about 216 one-pound retail packages of raisins of known composition (tables 1 and 2). Eighteen packages from each lot of each product were placed in each of 12 chambers which were maintained at constant temperatures (35°, 50°, 70°, 90° F.) and relative humidities (40, 60, and 80 percent); three packages were withdrawn at each sampling interval.

Measurements of the changes are reported for color, gross weight and moisture, sugar content, flavor, texture, sulfur dioxide, and visual changes such as sugaring and growth of micro-organisms. The experiments were continued for various lengths of time, depending on the temperature, until further storage would not provide useful information. The methods were as follows.

Alcohol Extractable Color

A 15-gram sample of well mixed ground dried fruit was placed in a 300-ml. Erlenmeyer flask containing 200 ml. of 50 percent ethanol. The flask was then covered with Parafilm [2] and allowed to remain at room temperature (68-72° F.) for 23 hours with occasional shaking. The colored solution was then filtered through Whatman No. 2 filter paper [2] and the color reading made with the aid of a Bausch and Lomb spectrophotometer (Spectronic 20) [2] at 440 mμ with a 1.2-cm. cell. The results were recorded in absorbance units ($A = \log_{10}\frac{1}{T}$) with a 50 percent ethanol solution used for zero adjustment. These results were converted to a moisture-free basis by division of the observed absorbance value by the fraction of the original sample that was total solids.

Moisture Determination

Moisture determinations were made by the vacuum-oven method. The procedure employed, with some modification, was that of the Association of Official Agricultural Chemists (1) and Makower, Chastain, and Nielsen (12).

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[2] Mention of specific products does not imply recommendation by the U.S. Department of Agriculture over others of a similar nature not mentioned.

A number of analyses were also made with the Dried Fruit Association moisture meter (DFA meter)[3] in order to compare the two methods. The fruit was prepared for analysis by blending the contents of three 1-lb. packages. It was ground in a food chopper driven by a 1/4-horsepower electric motor. The food chopper has a 19-tooth rotary cutting head 2-1/2 inches in diameter. The ground fruit was placed immediately in a sealed container.

In the vacuum-oven determinations a 4-gram sample of well blended ground dried fruit weighed accurately to 1 mg. was placed in a moisture dish containing 5 grams of washed and ignited coarse sand and a short stirring rod. The sand provides the means for increasing the drying surface of the sample. The contents of the moisture dish were stirred and well mixed. (The rod was not removed during the course of moisture determination.) The dish was placed on a steam bath for 15 minutes and then transferred to the vacuum-oven and dried for 30 hours at 60° C. at less than 2 mm. Hg. pressure. Moisture is expressed as percentage of original sample weight.

Sugars

The method of Munson-Walker (1) was employed for total and reducing sugars and that of Williams and Potter (20) for fructose determinations. Sucrose and glucose were determined by difference.

Visual and Tactile Changes

The samples withdrawn for various analyses were examined for changes in texture, occurrence of sugaring, and growth of micro-organisms.

Weight Changes in Retail Packages

Four commercially packed retail packages of each dried fruit packed in K202 bags and four in cartons with foil-laminated paper overwrap were weighed periodically throughout the experiments to the nearest 0.5 gram. The weight changes in these unopened packages are expressed as percentage of the original weight.

Flavor

Representative samples of dried fruits were withdrawn from the storage chambers at various intervals, hermetically sealed in No. 2 cans, and stored at -30° F. for subsequent determination of flavor changes by a laboratory taste panel as well as by a panel of members of the raisin industry. Control samples were kept at -30° F. for the comparisons made by triangle taste tests (7).

[3] Dried Fruit Association of California.

Sulfur Dioxide

The SO_2 content of Golden Bleached raisins was determined by the gravimetric Monier-Williams procedure (13) and by the Nury, Taylor, Brekke method (16). Data reported were obtained by the latter method.

Reflectance Color

The Golden Bleached raisins were analyzed for reflectance color as determined by the Hunter Color and Color-Difference meter[2] which was set to a reference tile, National Bureau of Standards SBC 35, with values for Rd, a, and b of 54.0, +1.0 and +32.0, respectively. A sample of well mixed and ground dried fruit was packed 1/2 inch deep in a round cell 3.3 inches in diameter. Reflected light readings for Rd, a, and b values were taken through a 2.25-inch circular opening in the cover plate while the sample cell rotated at about 115 r.p.m. (10).

Results with Regular Raisins

Color Changes

Although ordinary (not bleached) raisins are naturally dark and further darkening is difficult to distinguish visually, it is possible to measure these changes by chemical analyses. An objective study of color provides an excellent criterion of quality and is also the best indicator of time-temperature experience of raisins.

Under the conditions employed, humidity of storage was found to have little or no effect upon the color changes of raisins. For this reason, the color data presented here are on raisins stored at 60 percent relative humidity and at 35°, 50°, 70°, and 90°F. Figures 1 and 2 represent analyses of color extractable with 50 percent ethanol for raisins stored under these conditions. It is evident that at 90°F. storage, darkening occurs very rapidly. After 15 months at 50°F., the darkening approached that of raisins stored at 90°F. for less than 1 month and of raisins stored at 70°F. for 3 months. The extent of darkening at 15 months at 70°F. equalled that of 90°F. storage after 3 months.

In nearly all cases, the bagged fruits darkened at a slightly lower rate than the fruit in cartons. An absorbance value of about 1.0 (moisture-free basis) correlates closely with the point at which the authors considered the raisins to be doubtful in acceptability.

Moisture and Weight Changes

Moisture changes in raisins in retail packages are due to several major factors: temperature, humidity, initial moisture content, and the

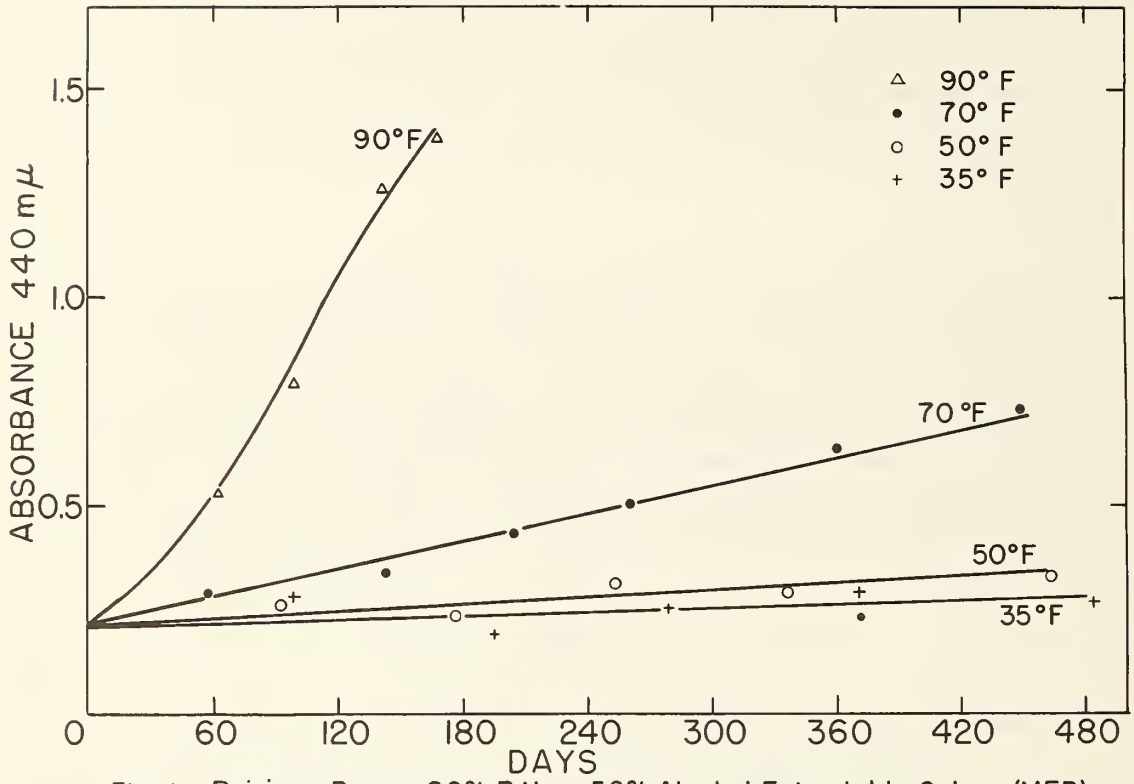

Fig. 1 Raisins, Bags, 60% R.H. 50% Alcohol Extractable Color (MFB)

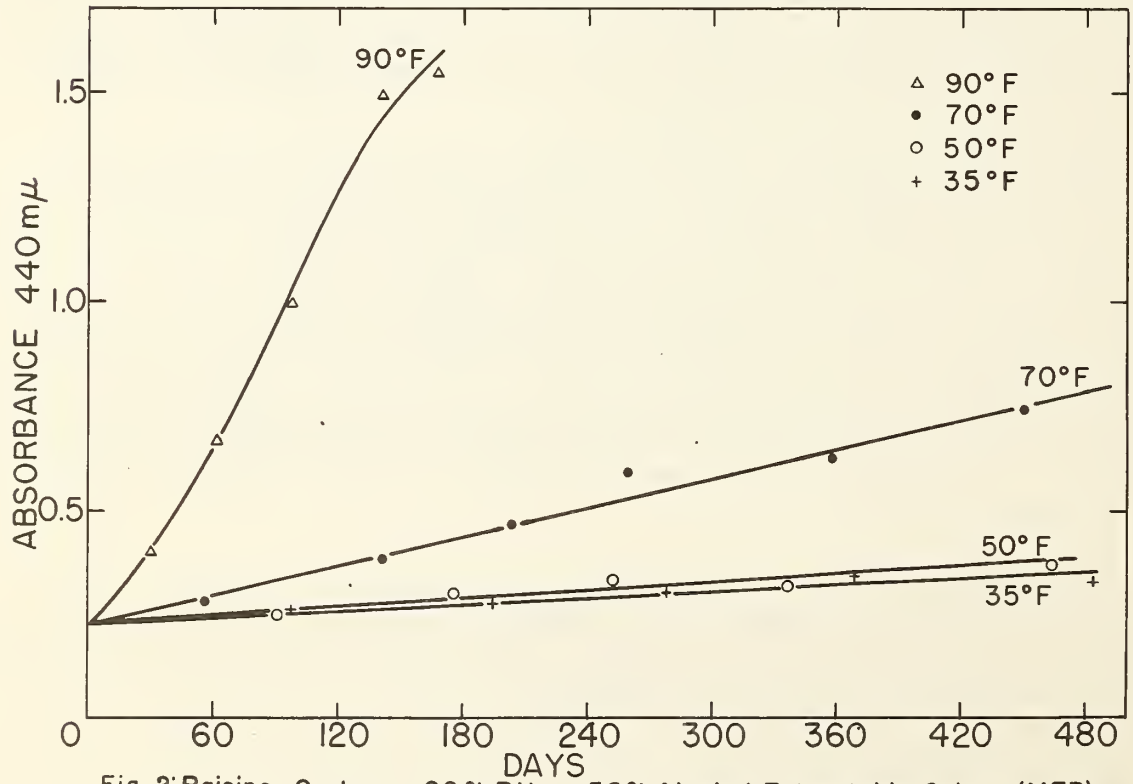

Fig. 2: Raisins, Cartons, 60% R.H. 50% Alcohol Extractable Color (MFB)

type of container. Moisture analyses are subject to several errors, one of which is due to lack of homogeneity in the samples. For this reason, gross weight changes were also recorded on several unopened retail packages throughout the experiment. Figures 3 to 8 show the gross weight changes, which indicate moisture changes as well. The changes were greater generally for fruits packed in K202 bags than for carton-packed fruits and indicate the higher rate of moisture vapor transfer of the bags.

Weight losses of about 2 to 3 percent were recorded at 40 percent relative humidity and 70° and 90° F. in bagged raisins, while gains of about 4 to 7 percent were noted at 80 percent relative humidity and 70° and 90° F. The weight changes at both 50° and 35° F. for all the relative humidities were very small.

Moisture determinations generally substantiated the observed changes in gross weight. The results of vacuum-oven analyses on the raisins at the termination of the experiments appear in table 3. Comparison of the

Table 3.--Moisture content of stored regular raisins determined by vacuum-oven method

(Initial moisture content: Cartons, 16.2 pct.; bags, 16.1 pct.)

Temperature	Storage	Relative humidity	Moisture	
			Cartons	Bags
Degrees F.	Days	Percent	Percent	Percent
90	165	40	14.7	13.9
		60	16.0	16.2
		80	16.2	18.6
70	440	40	14.6	13.4
		60	16.9	16.6
		80	17.7	19.8
50	460	40	14.8	14.5
		60	16.2	15.9
		80	16.6	18.4
35	490	40	15.1	14.9
		60	15.8	15.9
		80	16.4	17.5

vacuum-oven analysis with the conductometric method indicated that the latter usually gave somewhat higher results on regular Thompson Seedless raisins.

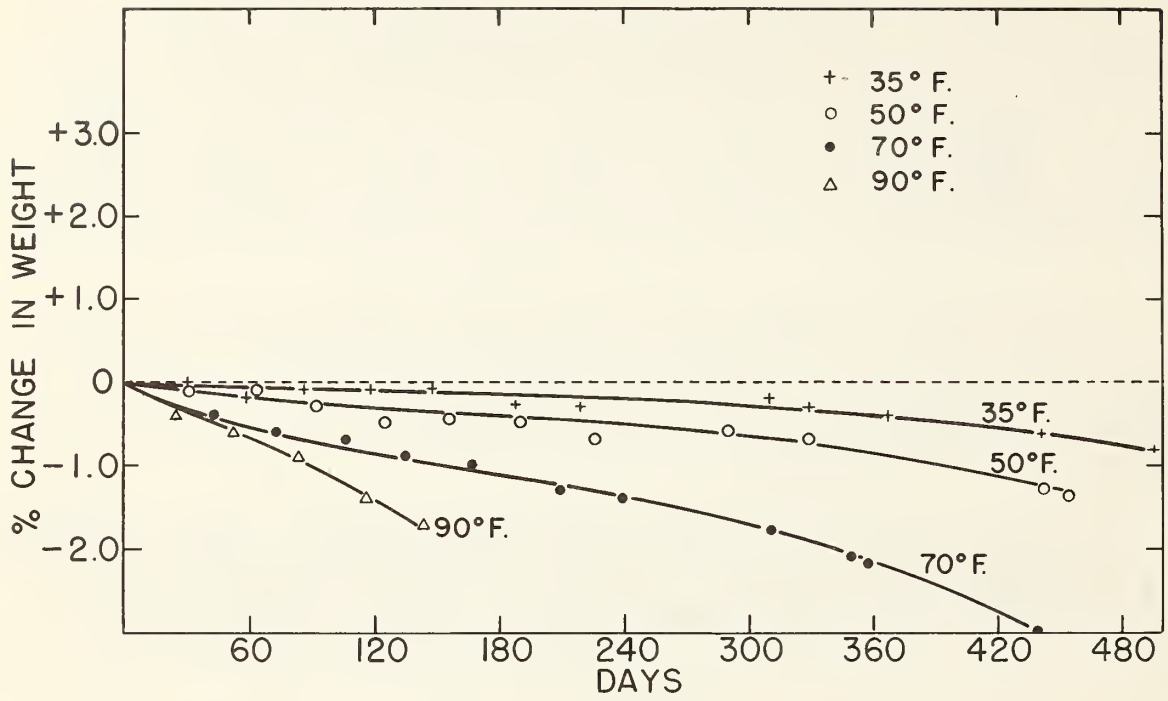

Fig 3: Raisins, Bags, 40% RH. Percent Change in Weight

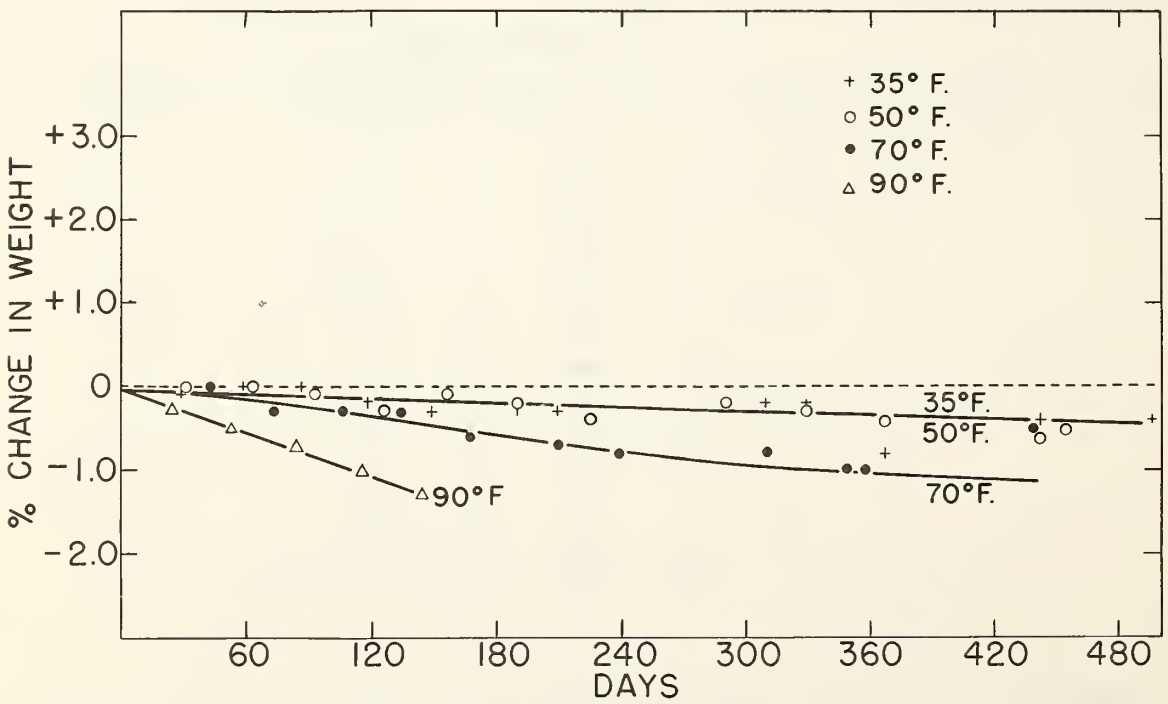

Fig 4: Raisins, Cartons, 40% RH. Percent Change in Weight

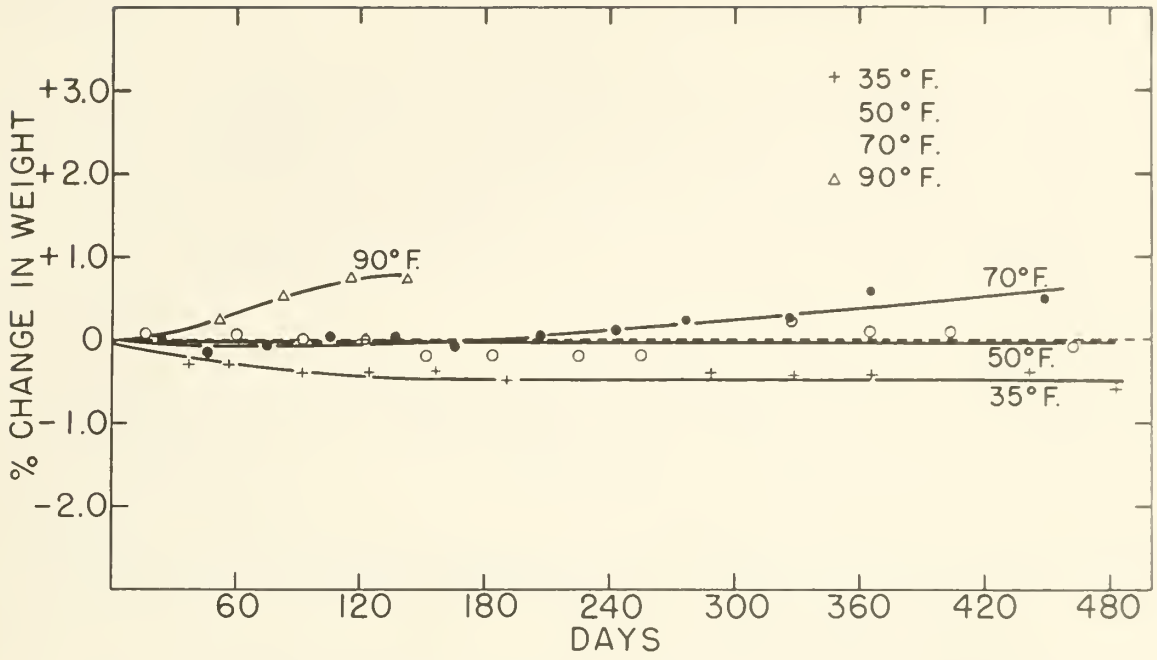

Fig 5: Raisins, Bags, 60% R H. Percent Change in Weight

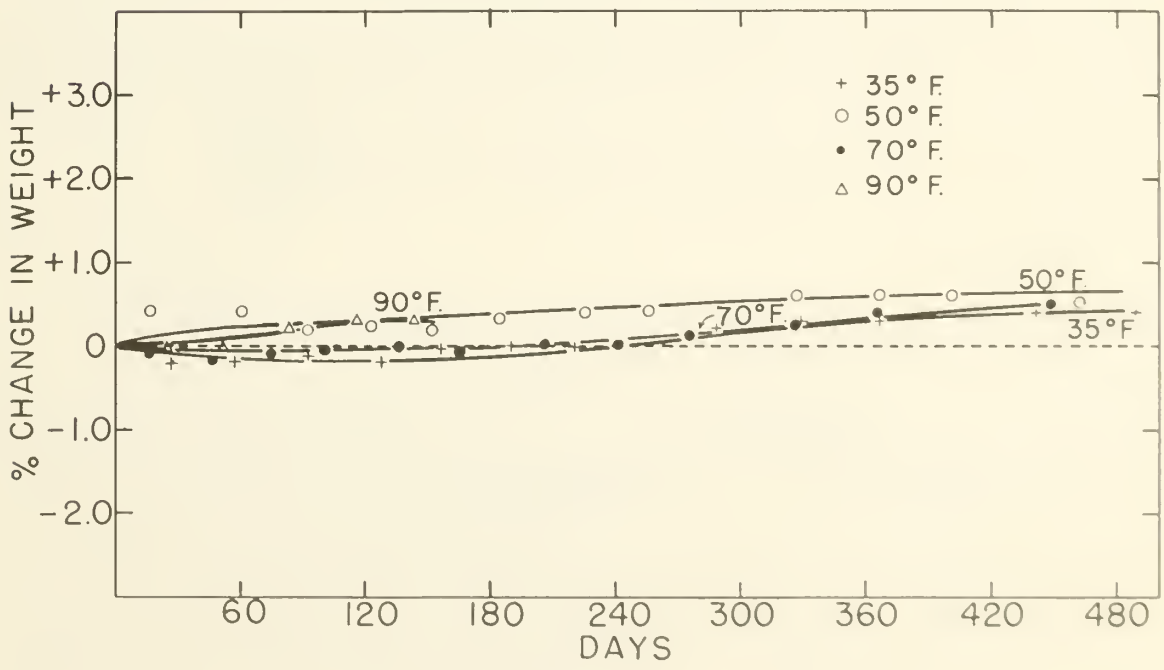

Fig 6: Raisins, Cartons, 60% R H. Percent Change in Weight

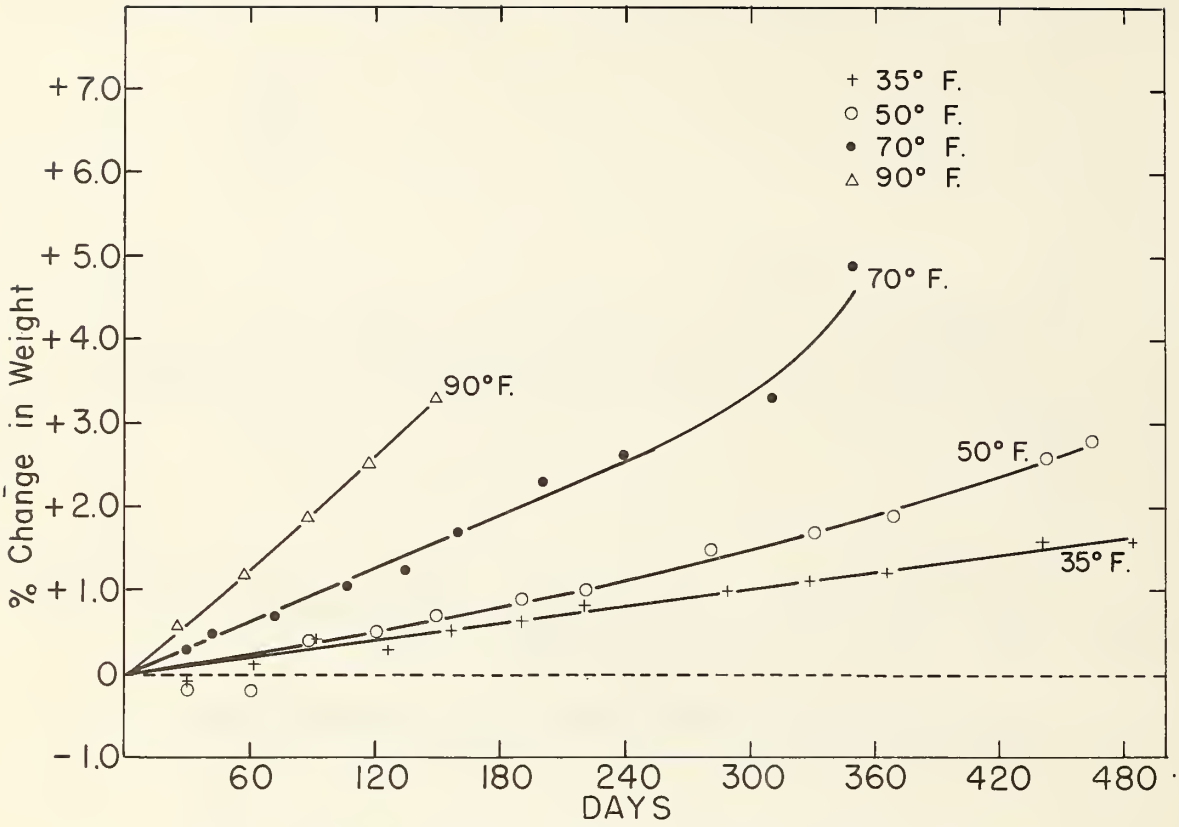

Fig. 7 Raisins, Bags, 80% R H. Percent Change in Weight

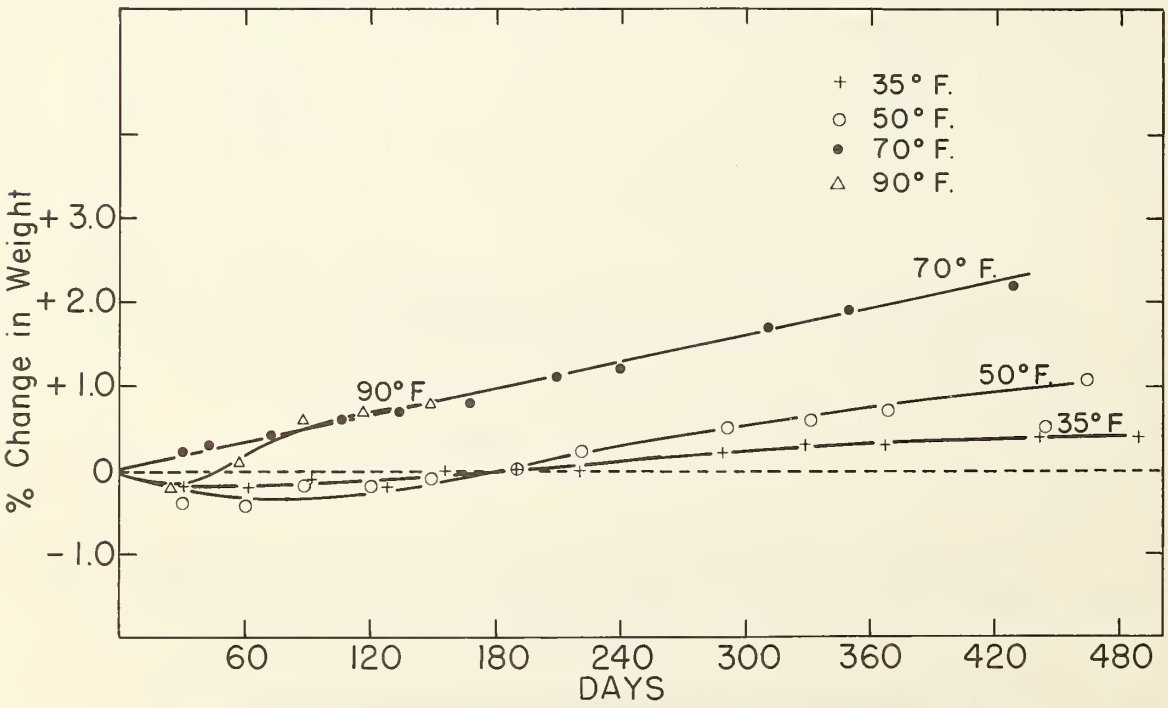

Fig 8: Raisins, Cartons, 80% R H. Percent Change in Weight

Flavor Changes

Bagged raisins stored at 90°F. for 84 days, at 70° F. for 140 days, and at 50° F. for 168 days, all at 60 percent relative humidity, were judged different from the control by triangle taste tests (7). An industry taste panel scored the control and those stored at 50° F. for 150 days as about equal in quality. Raisins stored at 90° F. for 90 days and those stored at 70° F. for 450 days were rated about the same by the industry panel.

Sugar Content

Sugar analyses showed no significant change in total or reducing sugars in raisins during the entire experiment.

Visual Appearance

None of the packages of raisins showed any sign of microbial growth and no insects were detected.

At 90° F. and 80 percent relative humidity some sirup accumulated in the packages. More sirup appeared in bags than in cartons; this was noted to a lesser degree for raisins stored at 90° F. and 60 percent relative humidity. Objectionable granular texture was noted in bagged raisins stored at 80 percent relative humidity and 70° F. after prolonged storage. The carton-packed fruit did not show this change. At 35° and 50° F. some of the bagged raisins showed signs of sugaring after 1 year. By means of paper chromatography, this hard grainy material was identified as glucose monohydrate in a matrix of concentrated fructose solution.

Results with Golden Bleached Raisins

Color Changes

Color plays an important role in grade and quality of Golden Bleached raisins. Information on color changes that take place under various atmospheric conditions is sought by many packers and handlers of this product. Figures 9 and 10 represent analyses of color extractable with 50 percent ethanol. The raisins were held at 60 percent relative humidity and 35°, 50°, 70°, and 90° F. No significant difference in the color of raisins stored at 40 and 80 percent relative humidity was noted when compared to the results at 60 percent relative humidity and corresponding temperatures. An extracted color absorbance value of about 0.3 (moisture-free basis) represented fruit darkening to the point where its acceptability was considered to be doubtful.

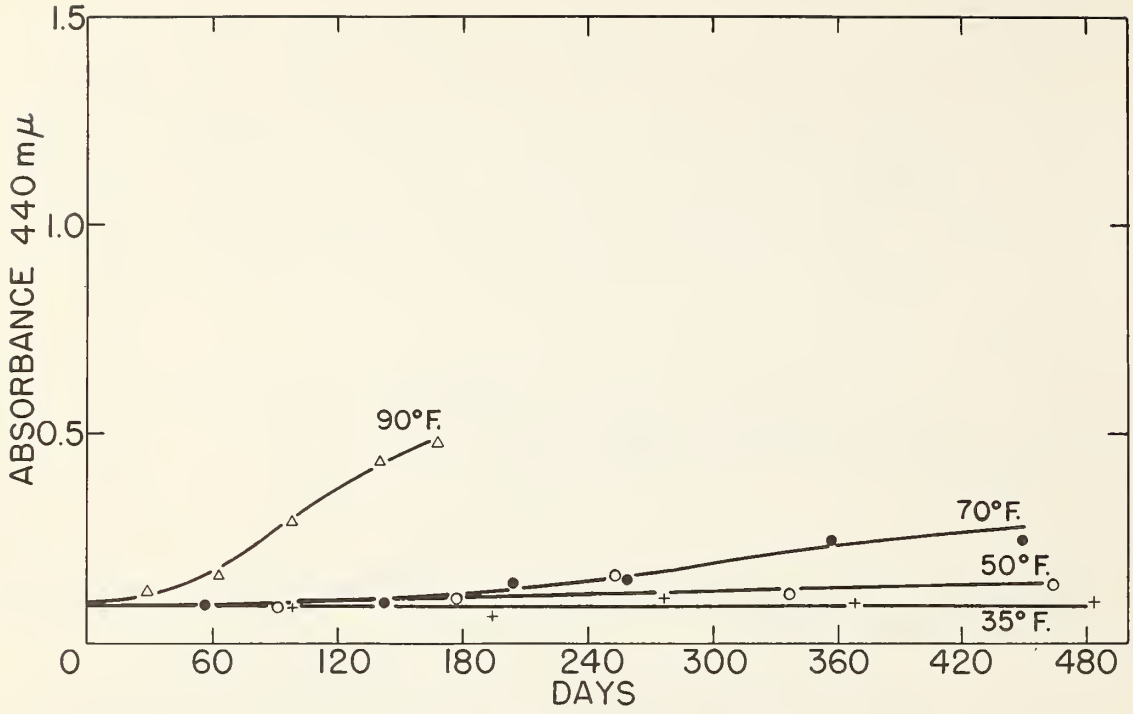

Fig. 9 Golden Raisins, Bags, 60% RH. 50% Alcohol Extractable Color (MFB)

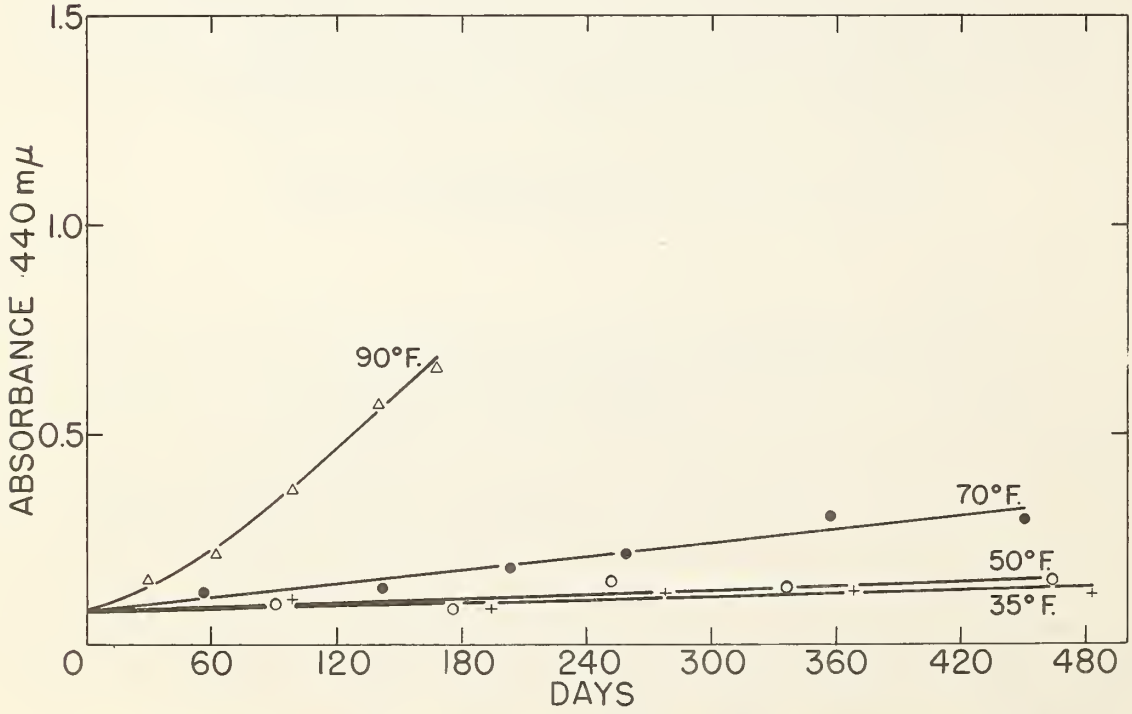

Fig. 10 Golden Raisins, Cartons, 60% RH. 50% Alcohol Extractable Color (MFB)

The extent of darkening after about 12 months at 70° F. was nearly equal that at 90° F. after 3 months. No significant difference in color was noted between golden raisins stored at 50° and 35° F. during the entire experiment. The results of reflectance color measurements as determined by Hunter Color and Color Difference meter[2] are shown in figures 11 and 12. As can be seen, the L values indicate initial bleaching of the color both at 70° and 90° F. and a more pronounced initial bleaching at lower temperatures of 50° and 35° F. Visually the fruits stored at 50° and 35° appeared lighter in color after a few months of storage.

Moisture and Weight Changes

Figures 13 to 18 show the results of gross weight changes in retail packages of Golden Bleached raisins. Weight gains of nearly 6 percent were recorded after 15 months at 70° F. and 80 percent relative humidity. At 40 percent relative humidity the weight losses were relatively small at all temperatures. As expected, the weight changes were dependent on temperature and relative humidity of the atmosphere as well as packaging type. Moisture determinations by vacuum oven were closely correlated with gross weight changes; the final results for 35°, 50°, 70°, and 90° F. storage are shown in table 4. For Golden Bleached raisins

Table 4.--Moisture content of stored Golden Bleached raisins determined by vacuum-oven method

(Initial moisture content: Cartons, 14.3 pct.; bags, 16.0 pct.)

Temperature	Storage	Relative humidity	Moisture	
			Cartons	Bags
Degrees F.	Days	Percent	Percent	Percent
90	165	40	12.8	14.9
		60	15.1	16.1
		80	18.2	18.2
70	450	40	13.1	13.1
		60	15.7	16.3
		80	17.9	19.8
50	460	40	13.8	14.1
		60	15.2	16.4
		80	15.9	17.9
35	480	40	13.5	14.8
		60	14.4	15.5
		80	15.1	16.7

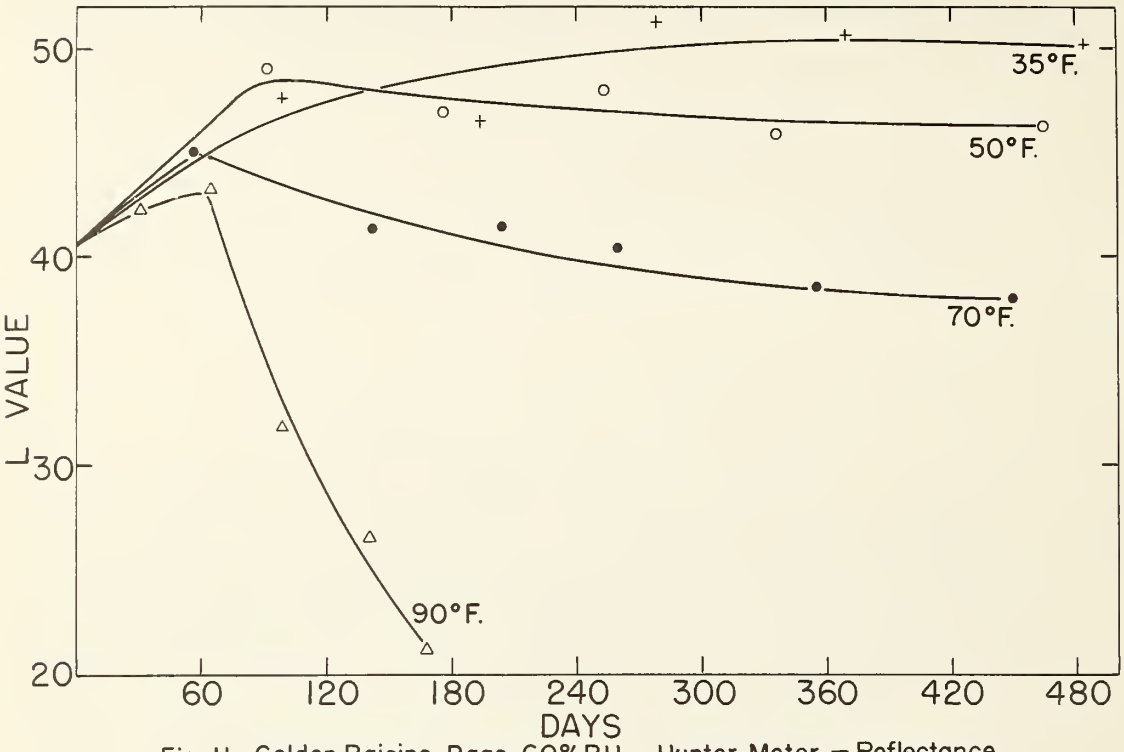

Fig. 11 Golden Raisins, Bags, 60% RH. Hunter Meter — Reflectance

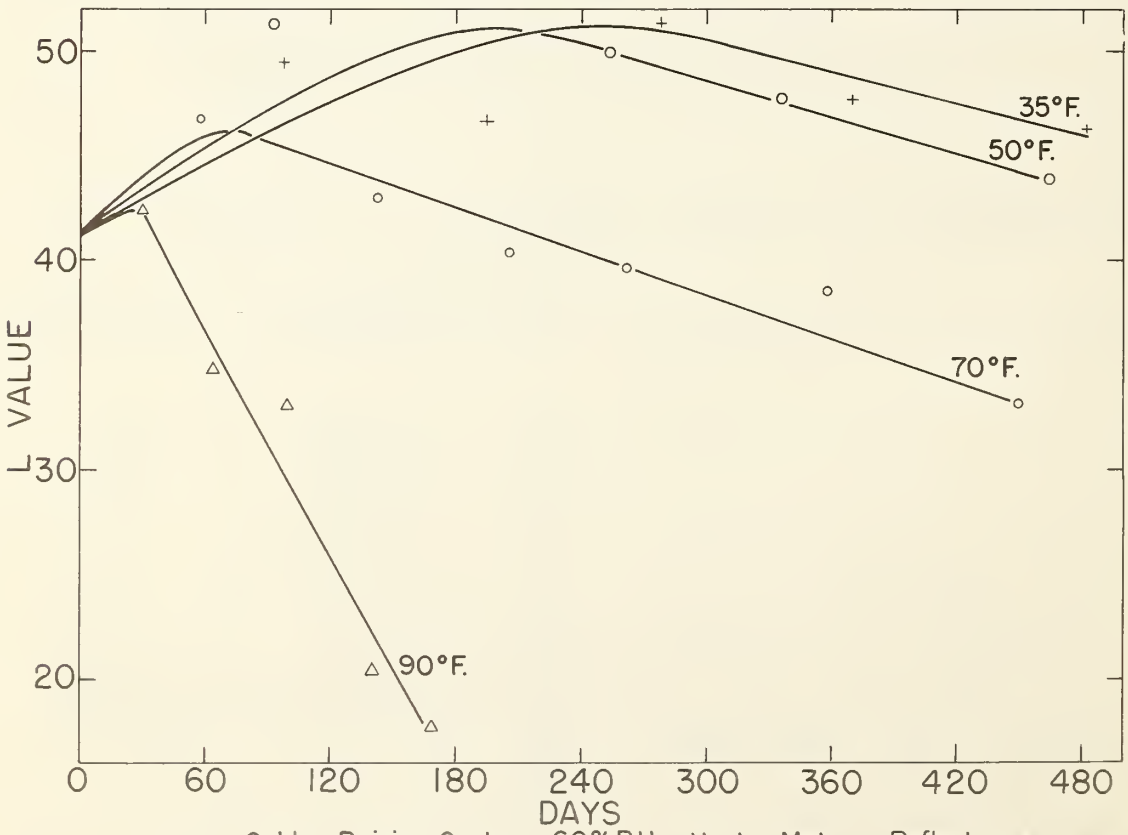

Fig 12 Golden Raisins, Cartons, 60% RH. Hunter Meter — Reflectance

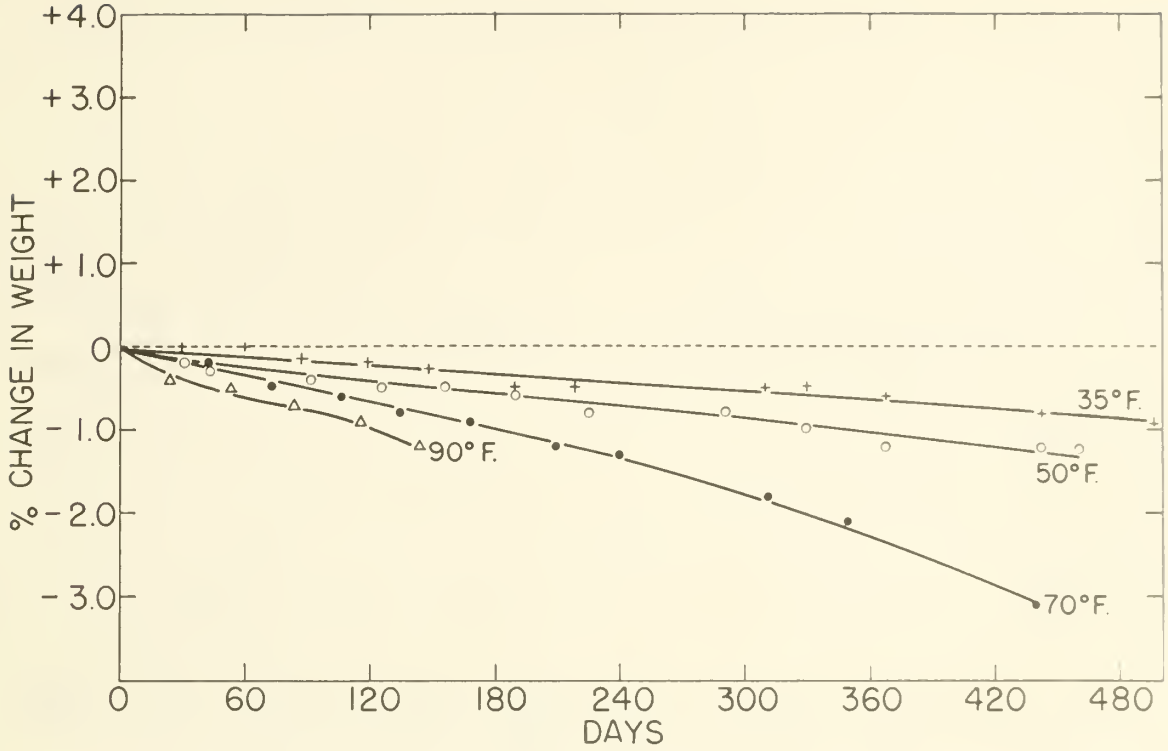

Fig. 13 Golden Raisins, Bags, 40% RH. Percent Change in Weight

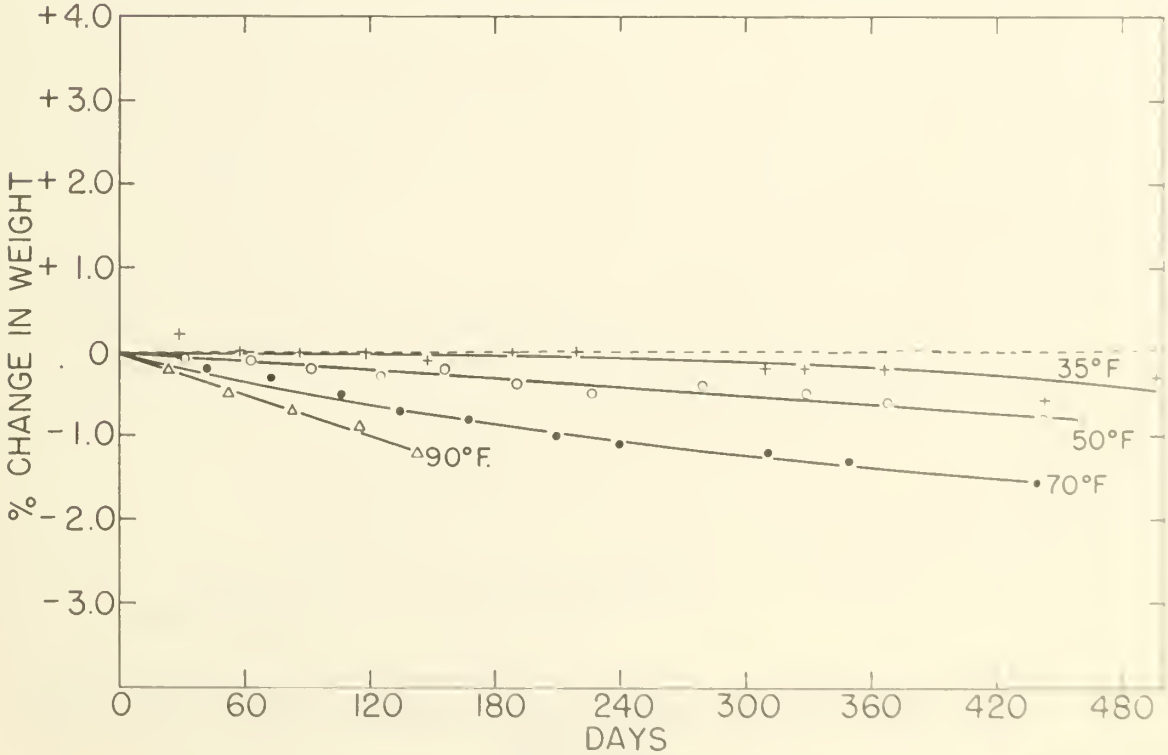

Fig 14 Golden Raisins, Cartons, 40% RH Percent Change in Weight

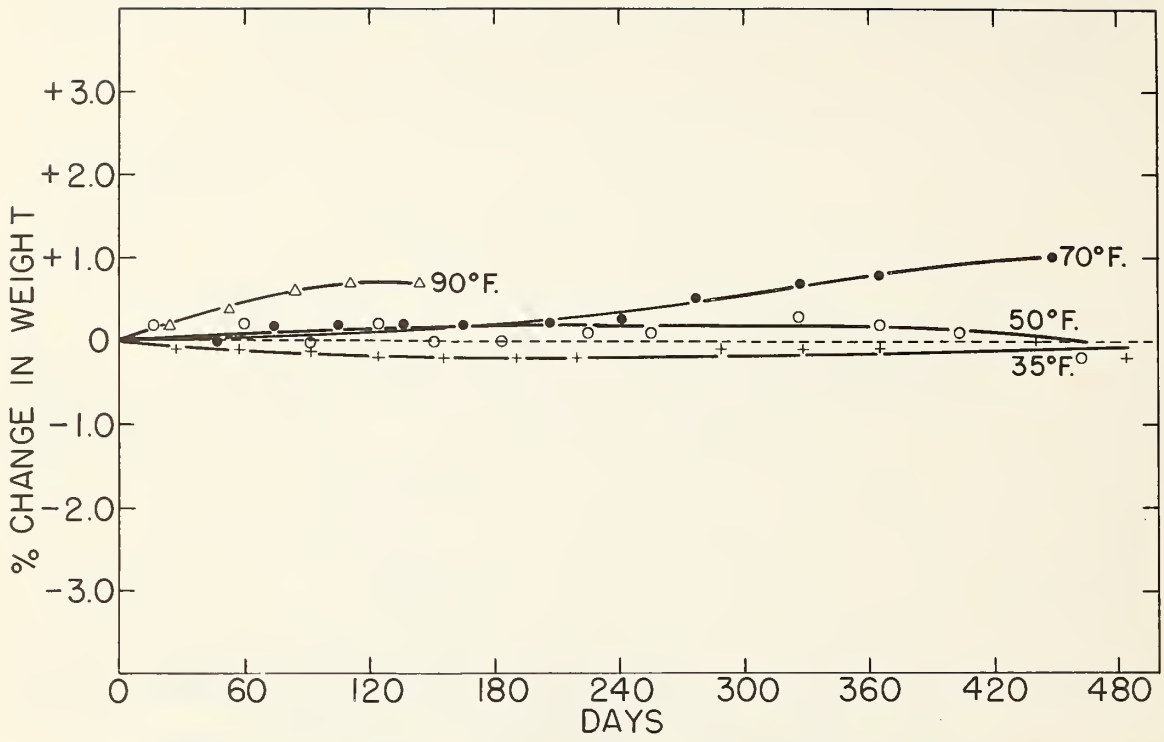

Fig. 15 Golden Raisins, Bags, 60% R H. Percent Change in Weight

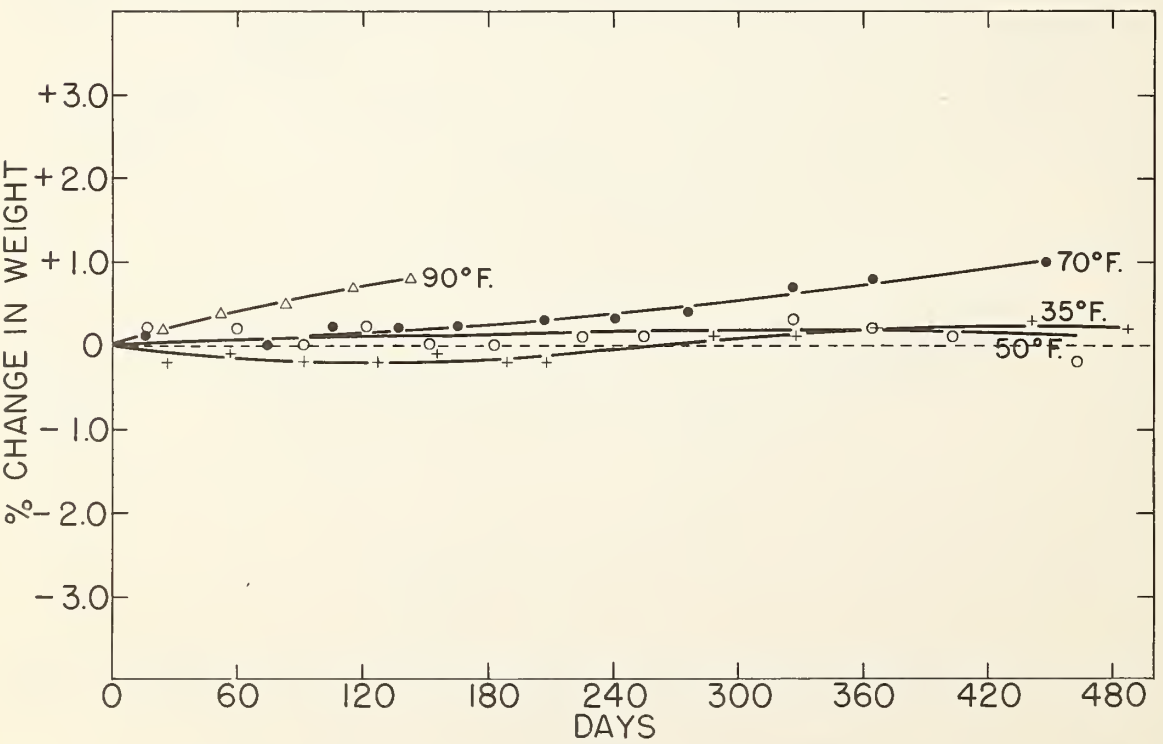

Fig. 16 Golden Raisins, Cartons, 60% RH. Percent Change in Weight

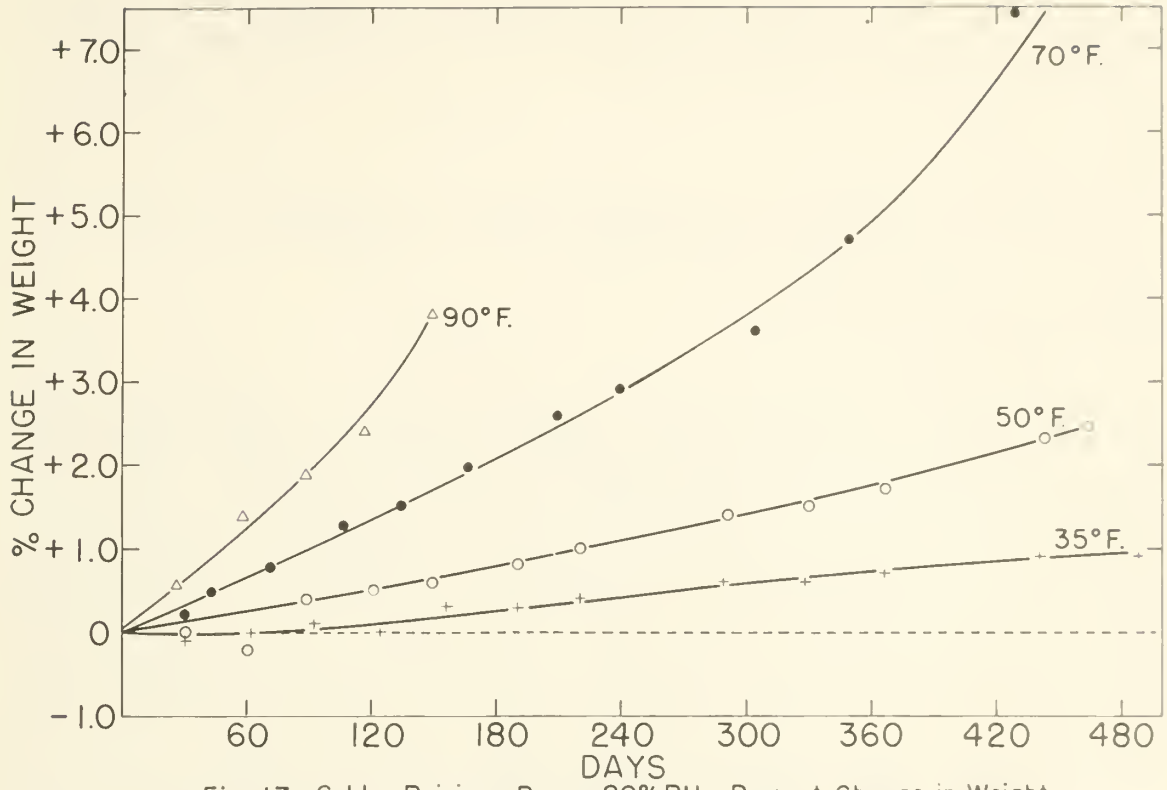

Fig. 17 Golden Raisins, Bags, 80% RH. Percent Change in Weight

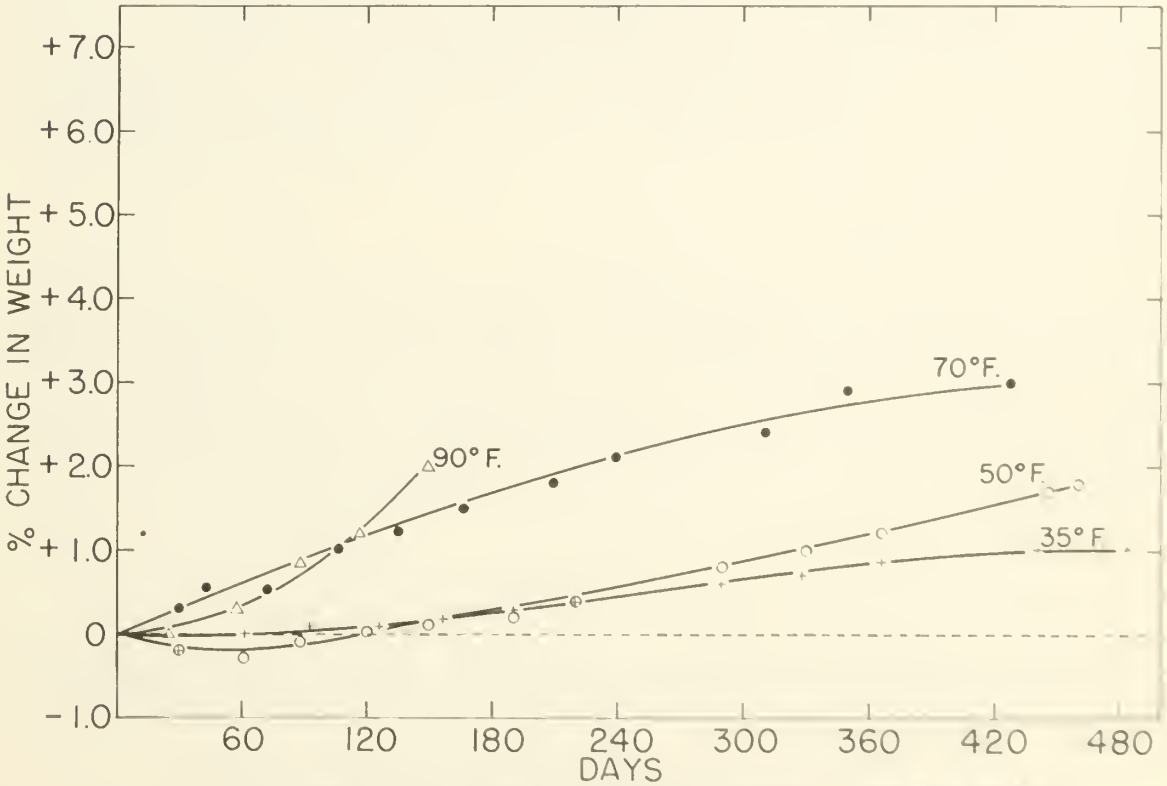

Fig 18 Golden Raisins, Cartons, 80% RH. Percent Change in Weight

the Dried Fruit Association moisture meter gave slightly lower values than the vacuum-oven method. This finding is in contrast with that for regular Thompson Seedless raisins.

Sugar Content Changes

Under the conditions of the experiment, no significant changes in total or component sugars were noted.

Visual Changes

Aside from darkening at higher temperatures, sirup formation and sweating at 90° F. and 80 percent relative humidity, the most important change occurred in K202 bags of golden raisins stored at 50° and 35° F. After about 8 months, subsurface and surface granulation or sugaring occurred at these temperatures and all relative humidities. The amount of granulation increased as storage continued. At the end of the study nearly all of the bagged golden raisins stored at 35° and 50° F. had an objectionable granular texture. A few samples held at 70° F. showed this granulation. It was not determined whether increase of relative humidity in the atmosphere was conducive to increased sugaring, although in a few cases it was observed that bagged Golden Bleached raisins stored at 50° and 35° F. and 80 percent relative humidity had sugared more extensively than those at lower humidities. With a very few exceptions, no sugaring occurred in carton-packed golden raisins. No insect growth was found in any of the packages. The carton-packed fruit maintained its overall quality at 35°, 50° and, for shorter periods, at 70° F. better than fruit packed in K202 bags.

Sulfur Dioxide Change

Changes in SO_2 content of Golden Bleached raisins under different atmospheric conditions can be seen in figures 19 to 24. The results show higher retention of SO_2 at lower temperatures. Relative humidity in the range of 40 to 80 percent did not appear to affect the rate of SO_2 loss significantly. Package type showed a minor effect on sulfur dioxide loss, but this was far outweighed by the effect of temperature.

Summary

Retail packages of regular and Golden Bleached Thompson Seedless raisins were held at 35°, 50°, 70°, and 90° F. and relative humidities of 40, 60, and 80 percent. Quality measurements were made on samples withdrawn at intervals.

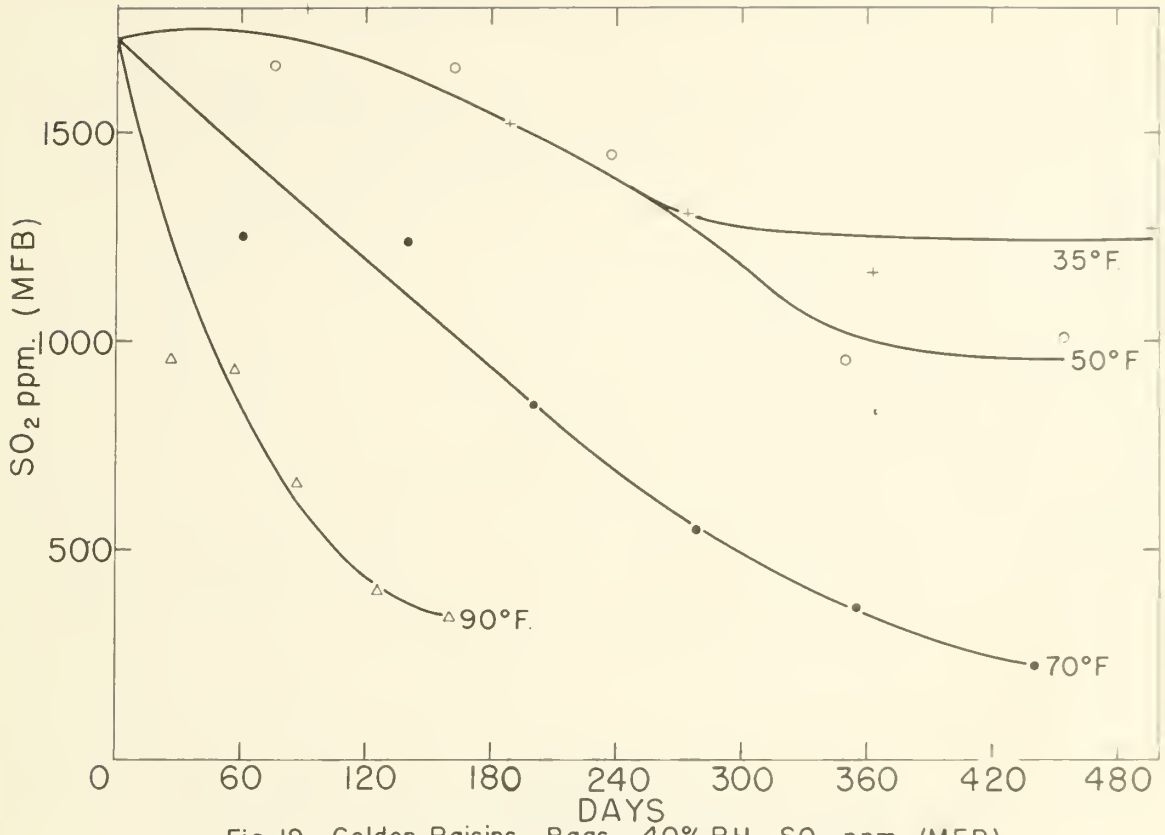

Fig. 19 Golden Raisins, Bags, 40% RH. SO_2 ppm. (MFB)

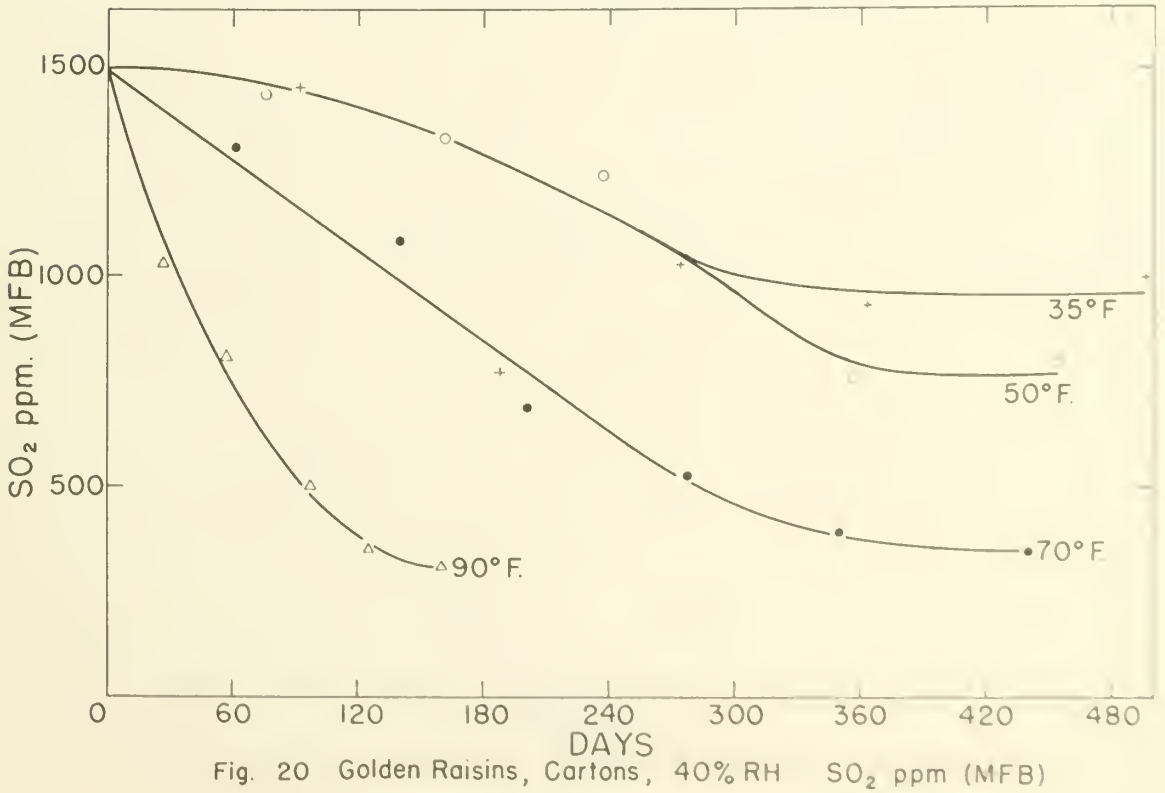

Fig. 20 Golden Raisins, Cartons, 40% RH SO_2 ppm (MFB)

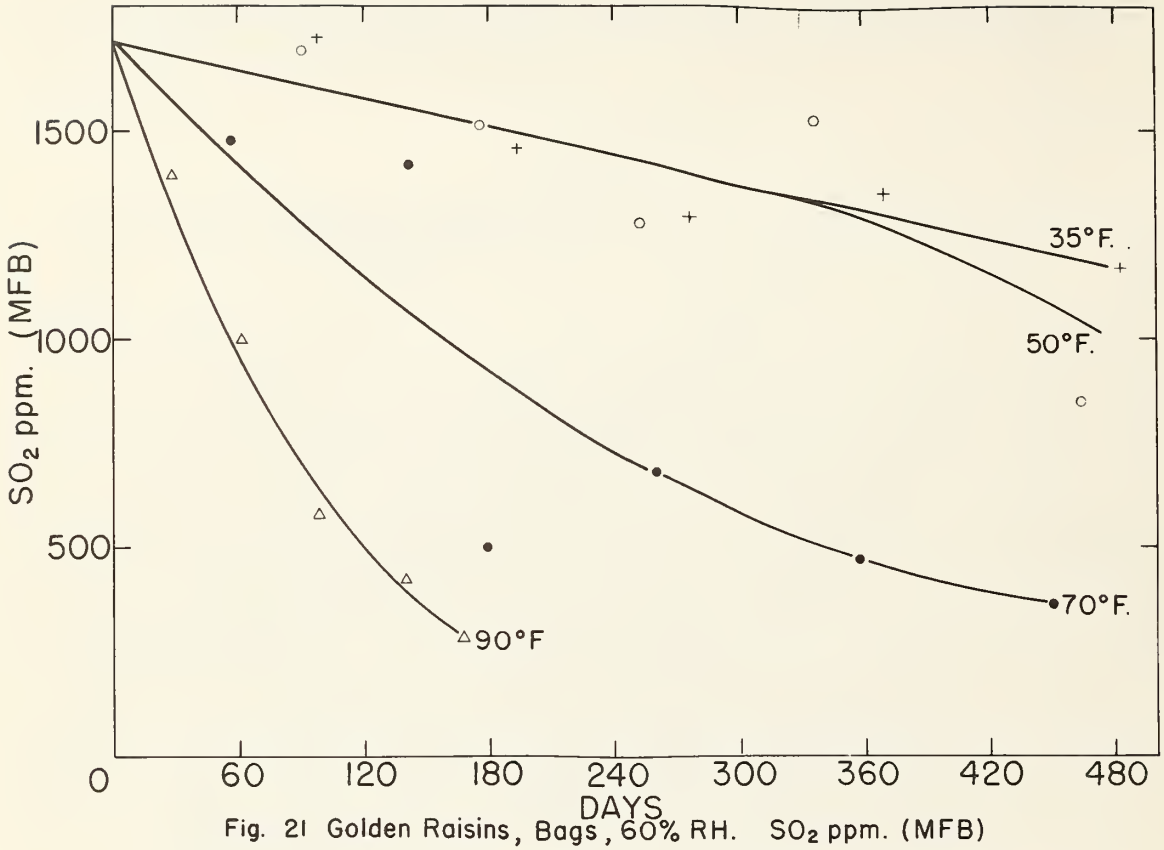

Fig. 21 Golden Raisins, Bags, 60% RH. SO_2 ppm. (MFB)

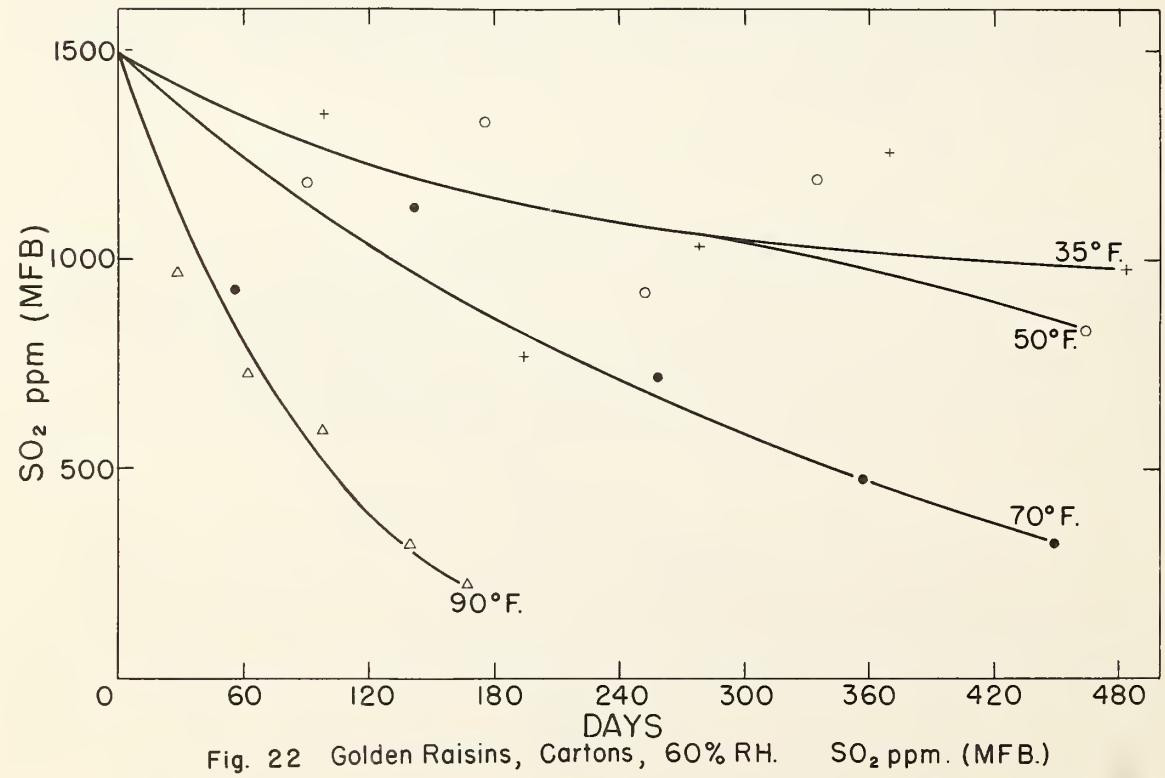

Fig. 22 Golden Raisins, Cartons, 60% RH. SO_2 ppm. (MFB.)

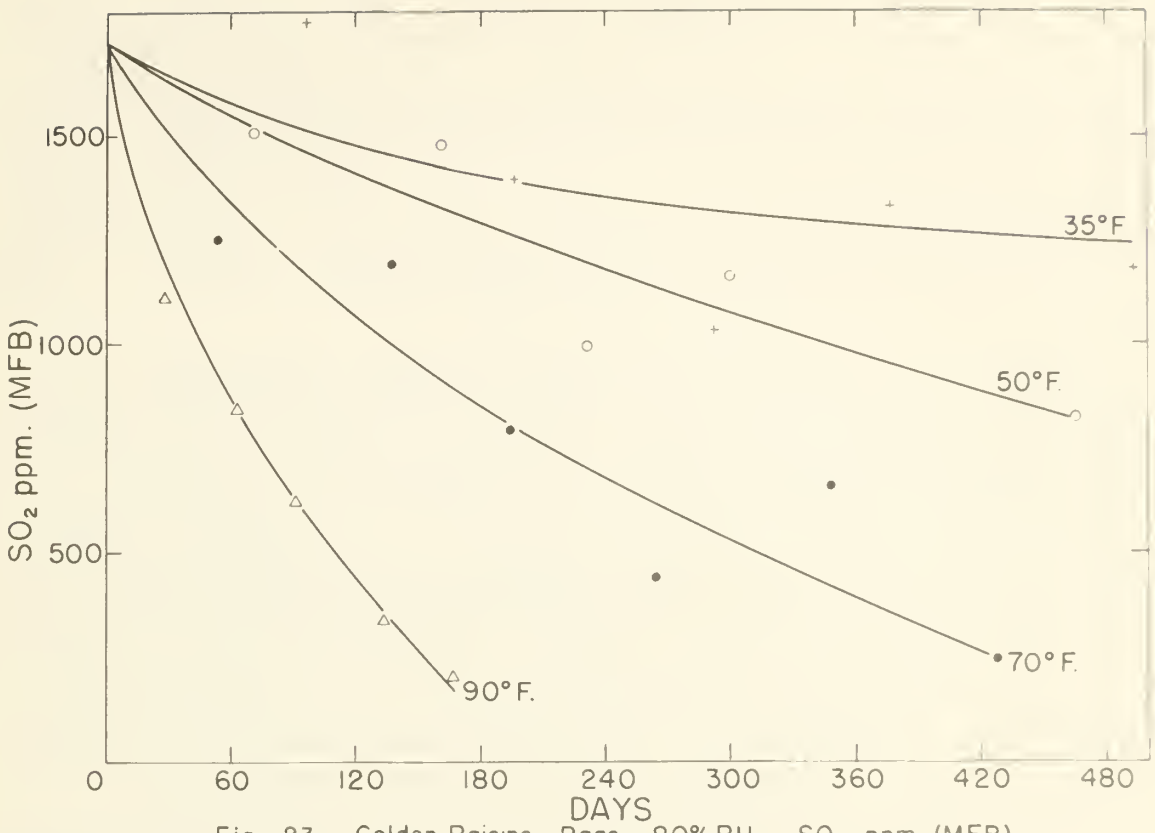

Fig 23 Golden Raisins, Bags, 80% RH. SO_2 ppm (MFB)

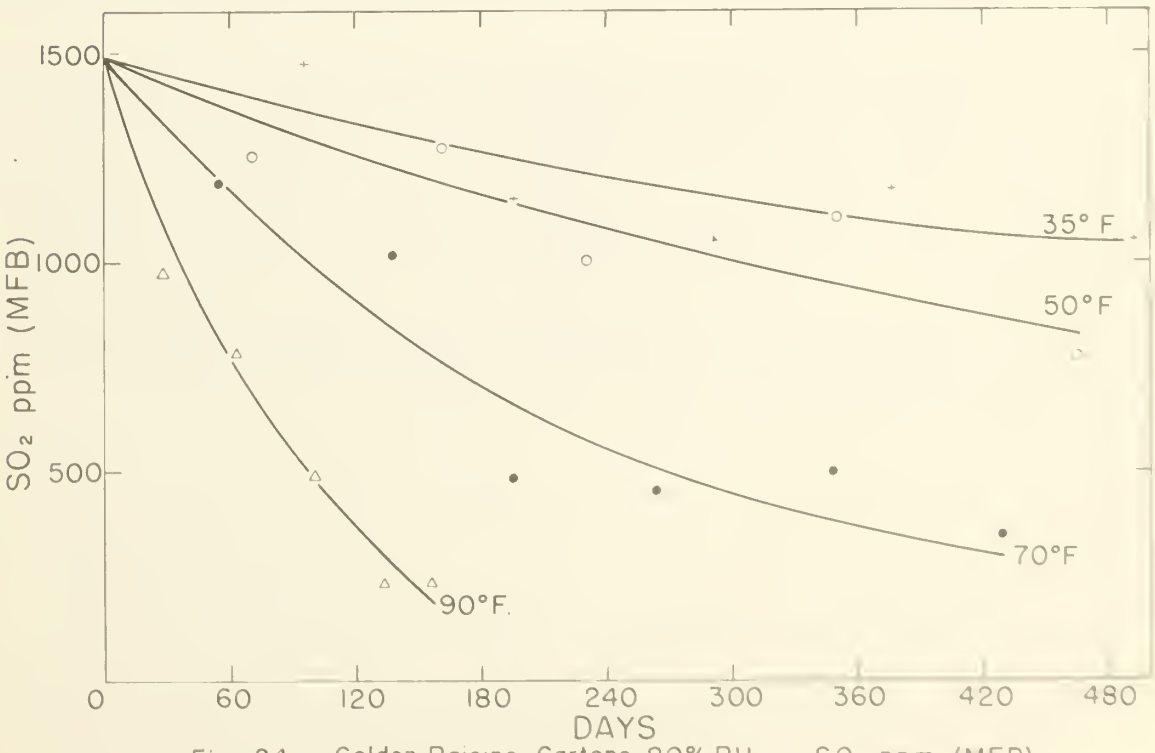

Fig. 24 Golden Raisins, Cartons, 80% RH SO_2 ppm (MFB)

Color changed independently of relative humidity in regular raisins both at 90° and 70°F. At 50° and 35°F. no significant color changes were noted. Significant moisture changes occurred at 70° and at 90°F. when the atmosphere was at 40 and 80 percent relative humidity, respectively. At lower temperatures, weight changes were very small. These changes were more pronounced in bagged fruits. Flavor tests by a laboratory panel and an industry panel indicate higher flavor retention at lower temperatures. Hard, grainy material (sugaring) accumulated in bagged raisins at 70°F. and 80 percent relative humidity.

In general, quality was maintained much better in carton-packed than bagged fruits, although the rate of discoloration was slightly higher in the former. Storage of cartons at 50°F. was satisfactory for the fruit, and no additional protection at 35°F. was apparent after 16 months. At 50° and 35°F. some of the bagged raisins showed signs of sugaring after about 12 months of storage. For this reason, low-temperature storage of bagged (K202) raisins would not be suitable for periods longer than a year. Processed regular raisins held for a year at 70°F. and 60 percent relative humidity retained their good quality. Organoleptic tests showed at what points stored raisins can be distinguished from a control group. Vapor-resistant packages, such as foil overwrapped cartons, generally maintained a higher quality than packages more permeable to vapor. In these experiments, carton-packed fruit was kept in excellent condition at 50°F. for 16 months at relative humidities in the range of 40 to 80 percent.

The results of chemical and quality changes in retail packages of Golden Bleached raisins stored under different atmospheric conditions are also presented. It is shown that color changes and sulfur dioxide losses take place independently of relative humidity; weight and moisture changes are affected by one or a combination of the following: packaging type, temperature, and relative humidity. Infestations of insects and micro-organisms were not encountered, and no changes in sugar content were noted. Extensive sugaring was observed in golden raisins packed in K202 bags and held at lower temperatures. In general raisins in cartons maintained quality much better than in bags.

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